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BIOMEDICAL ENGINEERING RESEARCH

In vitro measurements of apparent intrinsic viscosity in function of tube hematocrit and red blood cell velocity

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Introduction

The apparent intrinsic viscosity is a local parameter which can influence the pressure and flow field of an entire microvascular network. Previous studies tried to identify which factors could affect the apparent intrinsic viscosity but a general comprehension is not yet achieved. Moreover, to our best knowledge, most of the studies are computational [1,2] but only few are experimental [3]. Therefore, computational models of RBCs flow still have to be validated with experimental data.

In this study we aim at quantifying *in vitro* the apparent intrinsic viscosity of blood in function of hematocrit and RBC velocity.

Methodology

- Microdevice fabrication: conventional soft lithography
- Microchannel design: single straight channel with square cross-section (width=height=8μm)
- Microdevice was perfused with solutions of RBCs [4] (hematocrit 2.5% and 5%)
- Hydrostatic pressure heads to drive the fluid (4.5 cmH_2O and 7.5 cmH_2O)

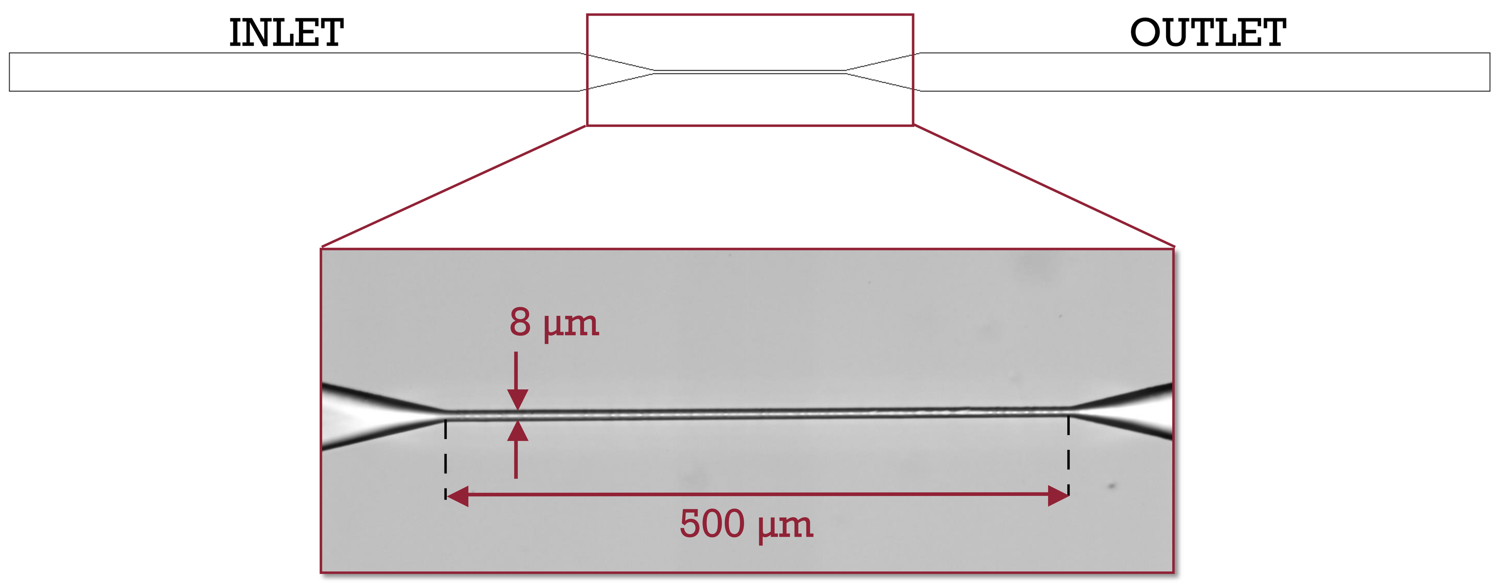
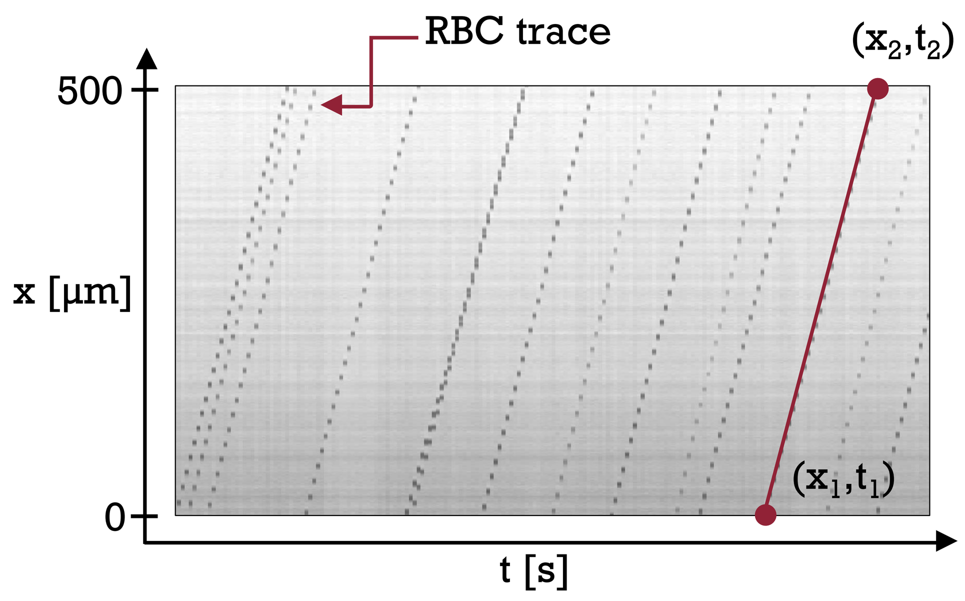


Figure 1: *Schematic of the microdevice. The section of interest is a single straight channel of 500 μm length with square cross-section.*

- Video recordings processing: line scans were stacked in a temporal sequence and RBC velocity was computed from the slope of the RBC traces in these stacks



$$u_{RBC} = \frac{x_2 - x_1}{t_2 - t_1}$$

Figure 2: *Example of a sequence of 200 frames (670 ms) showing a series of RBC moving through the whole length of the microchannel*

- Hematocrit (H_t) at each frame was derived as total volume of RBCs divided by the volume of the microchannel.
- Computation of apparent intrinsic viscosity (K_T):

$$K_T = \frac{1}{H_t}\left[\frac{u_{RBC}}{u_0} - 1\right]$$

where u_0 is the fluid velocity without red blood cells.

Results & Discussion

The results of experiments showed a monotonic decrease of the apparent intrinsic viscosity for a linear increase of the hematocrit (Figure 3). This trend has been reported in literature also in previous computational studies [1]. The overall mean value for K_T (1.79) is in line with the range reported either in theoretical [2] and numerical studies [1].

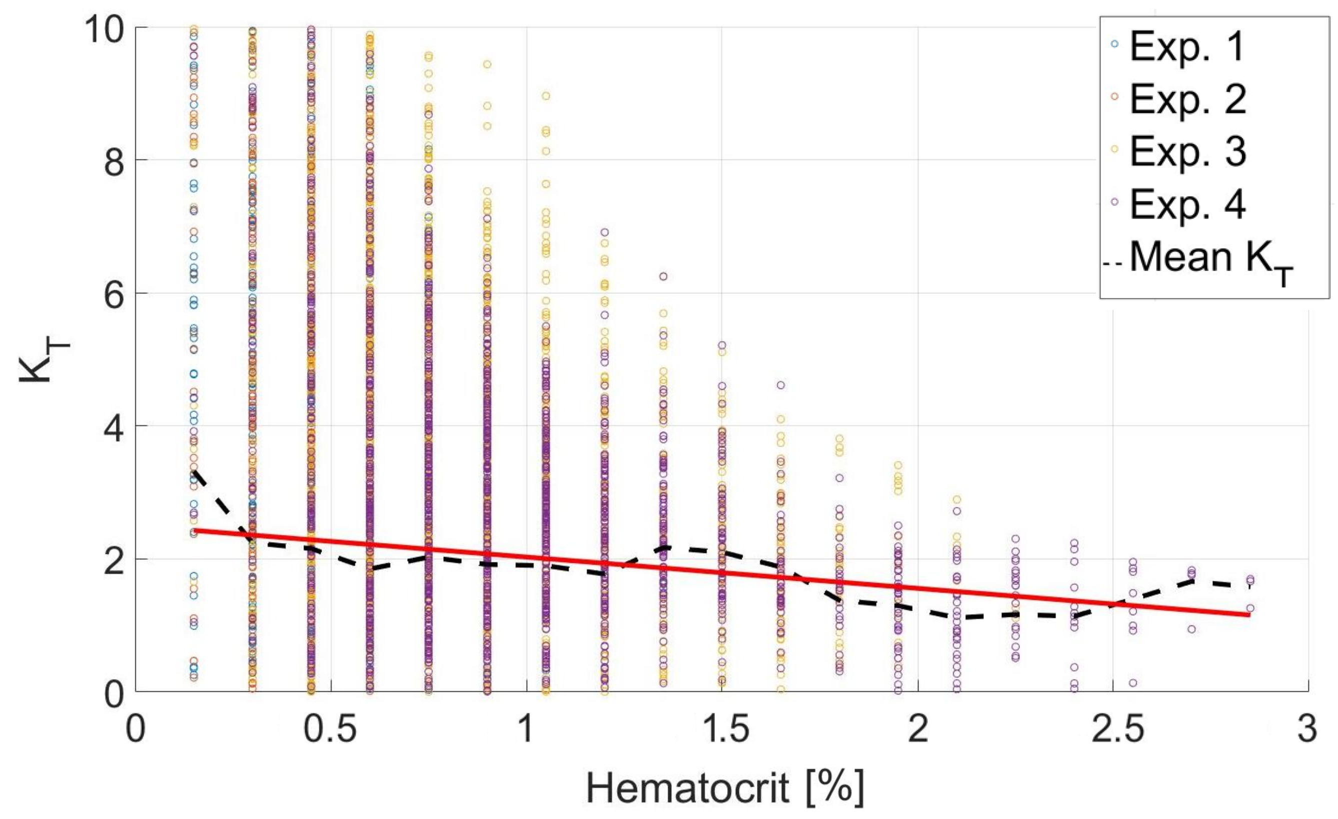


Figure 3 *Apparent intrinsic viscosity (K_T) in function of tube hematocrit. Black dashed line is the mean value of K_T for each value of H_t. The red line represents the linear regression of the mean values.*

In some cases the apparent intrinsic viscosity decreased when the inflow velocity increased (i.e Figure 4, Ht=2.2%). Despite of this result, no sufficient statistical evidence was found to generally state that K_T changes with RBC velocity.

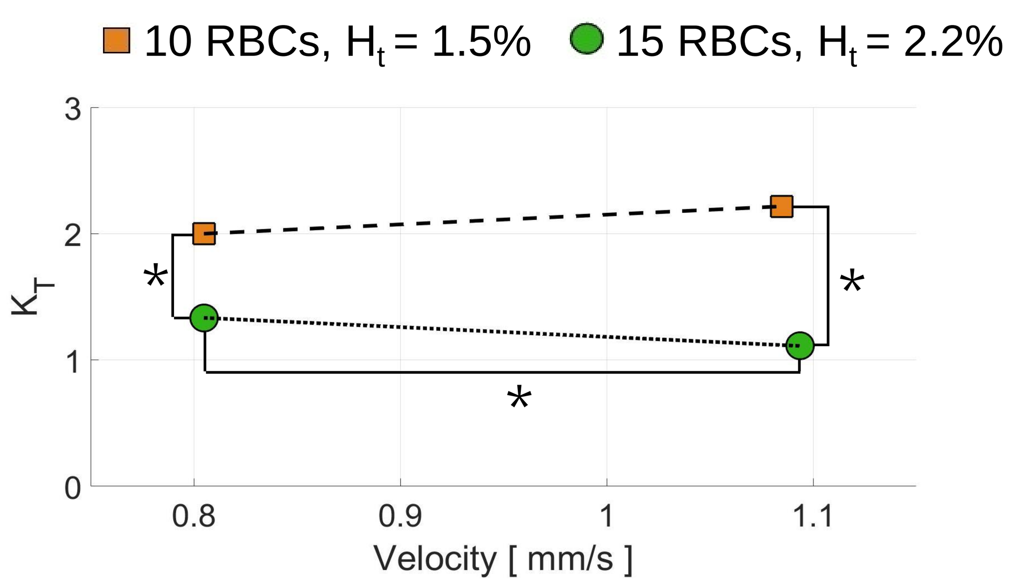


Figure 4 *Apparent intrinsic viscosity in function of velocity for two values of tube hematocrit (statistical significance: * p<0.05).*

Conclusion

This experimental study provided quantitative data for the apparent intrinsic viscosity and confirmed its dependence on local hematocrit as it was previously reported in numerical studies. Future experiments will be performed with circular channels and will take into account a wider range of hematocrit and RBC velocities.

References
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